Accuracy of the Home Energy Saver Energy Calculation Methodology

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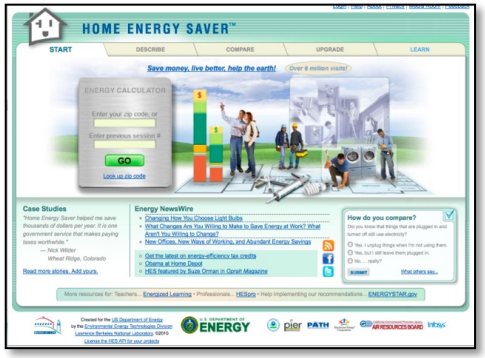
Presented at the 2012 ACEEE Summer Study on Energy Efficiency in Buildings, Asilomar, CA August 13-17

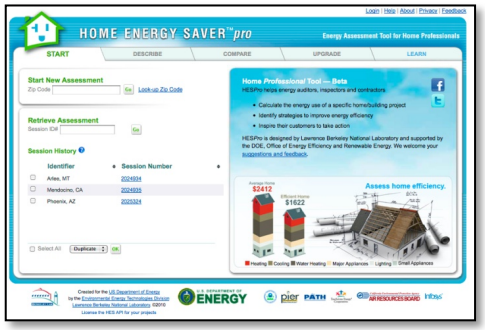
The Home Energy Saver Suite

- LBNL creates in early 1990s
- First web-based residential energy analysis tool
- Operational assessment (energy, cost, carbon)
- Hourly simulation using DOE-2.1E & other methods
- 7 million site visits so far
- API now used by 3rd-party developers

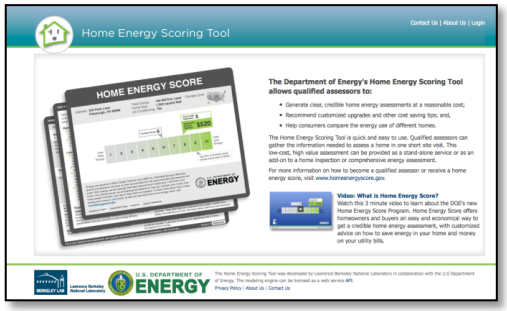
HESconsumer



HESpro

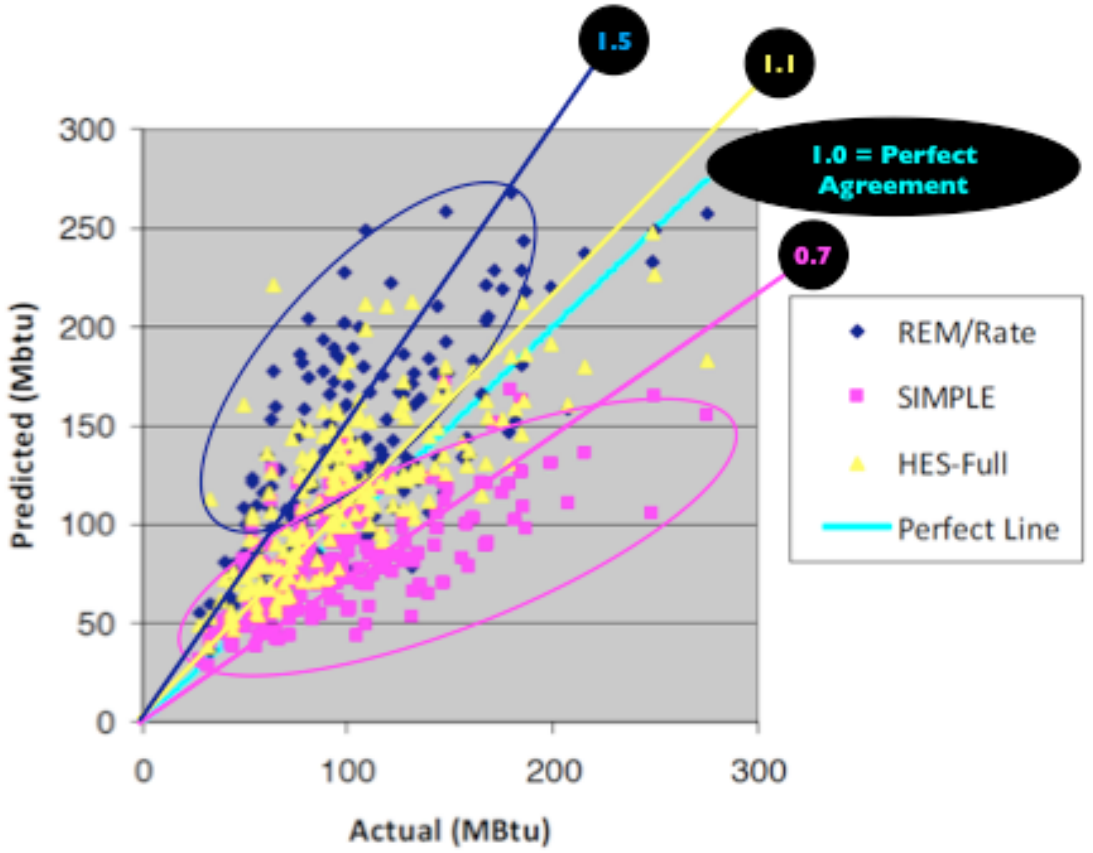


HEScore



Accuracy Misreadings

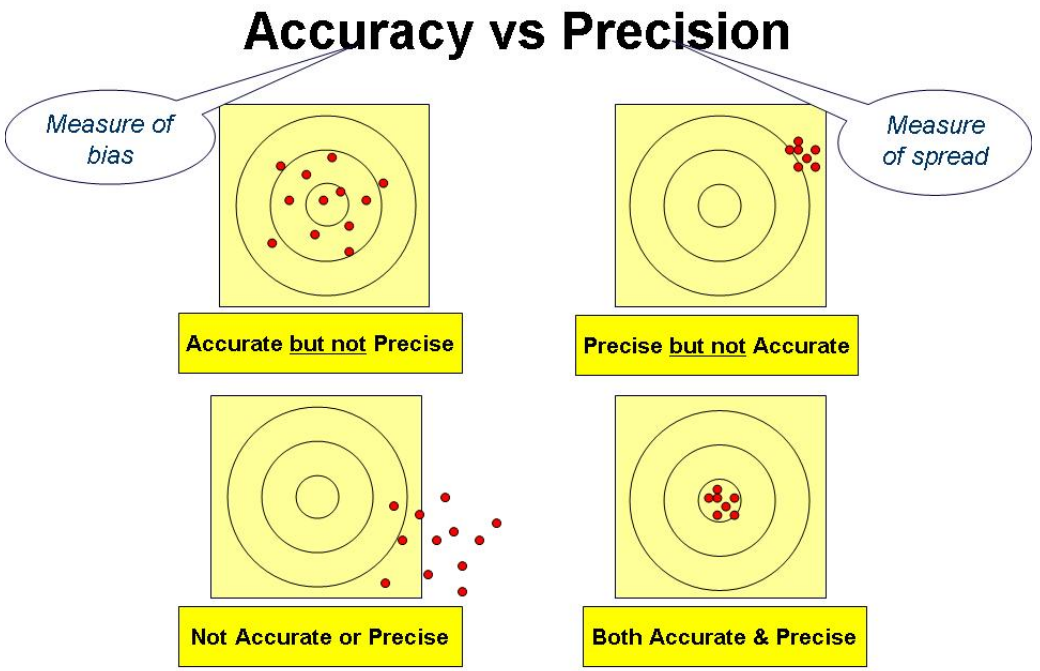
- Energy Trust of Oregon & CSG (2008) concluded that:
  - the tool in pink is more accurate than the tools in yellow & blue
  - more inputs do not make the analysis more accurate



Accuracy is Rarely Well-defined

Accuracy of What?

- Modeling
- Programming (bugs)
- Audit data
- Default values
- User inputs
- Measured data & weather



How is Accuracy Defined?

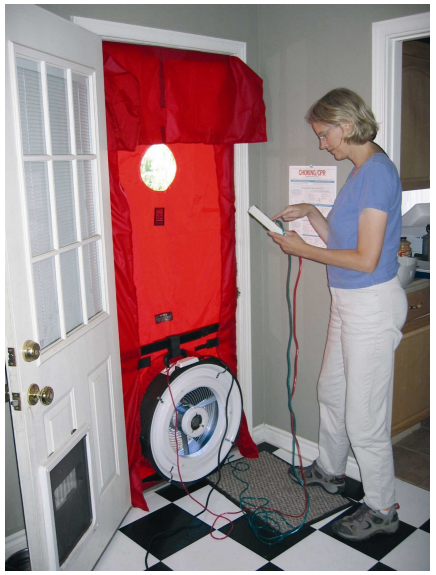
- Metrics
- Acceptable tolerance
- Whole-house *vs.* Fuel *vs.* End Use level
- Operational *vs.* Asset

Why is Accuracy Assessment being Done?

- Much depends on purpose of the analysis and how results are to be used
- Accuracy assessments are most valuable when used *during* model development *vs* after the fact

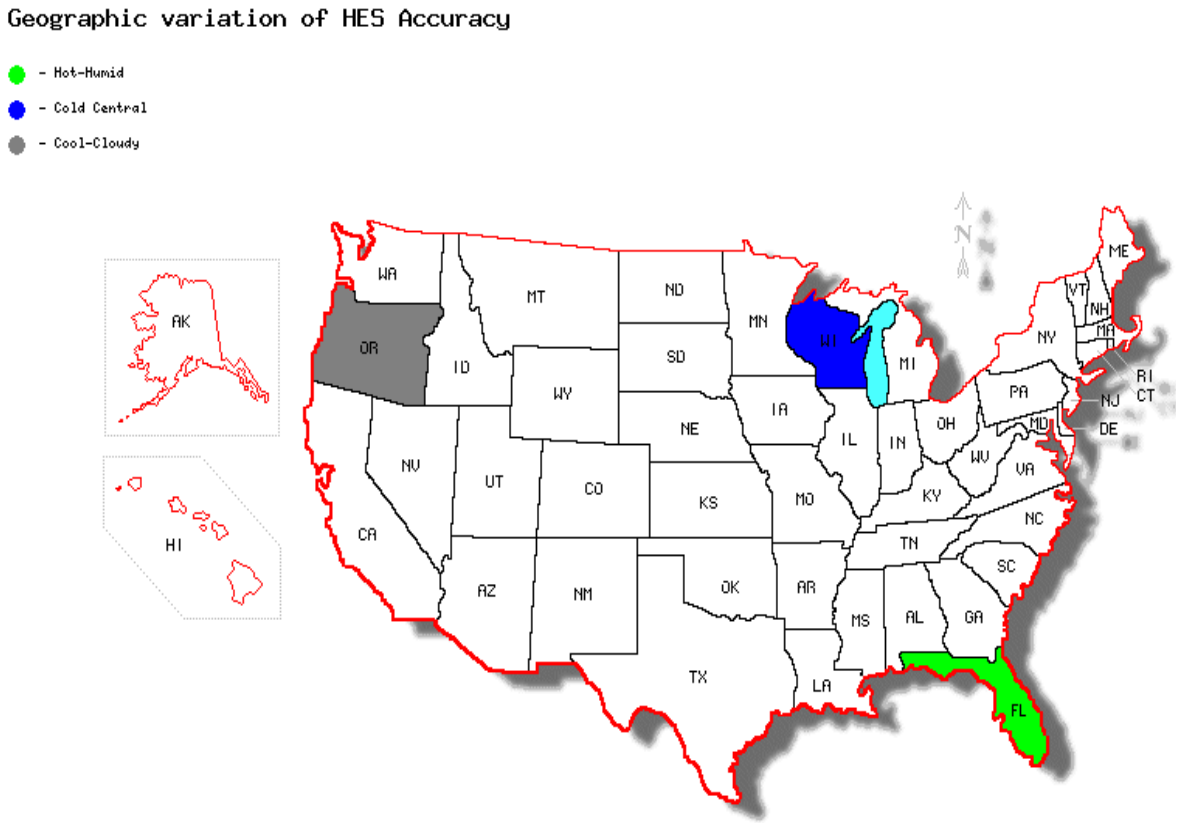
Asset vs. Operational Assessment

- Asset assessment (low information "drive-by" audit)
- Operational: classic on site energy audit
- This study focuses on Operational analyses
  - see Bourassa et al. for accuracy results of the Asset-based derivative of HES => HEScore



Model Accuracy Across Climates

- Operational analysis: 428 homes (QA'd down from 660)*
  - FSEC & NREL Data
- Model results compared to actual energy data
- Three climates
  - Florida (Hot Humid) – 2 cohorts
  - Wisconsin (Cold)
  - Oregon (Cool/ Cloudy)



* See https://sites.google.com/a/lbl.gov/hes-public/accuracy/decision-rules

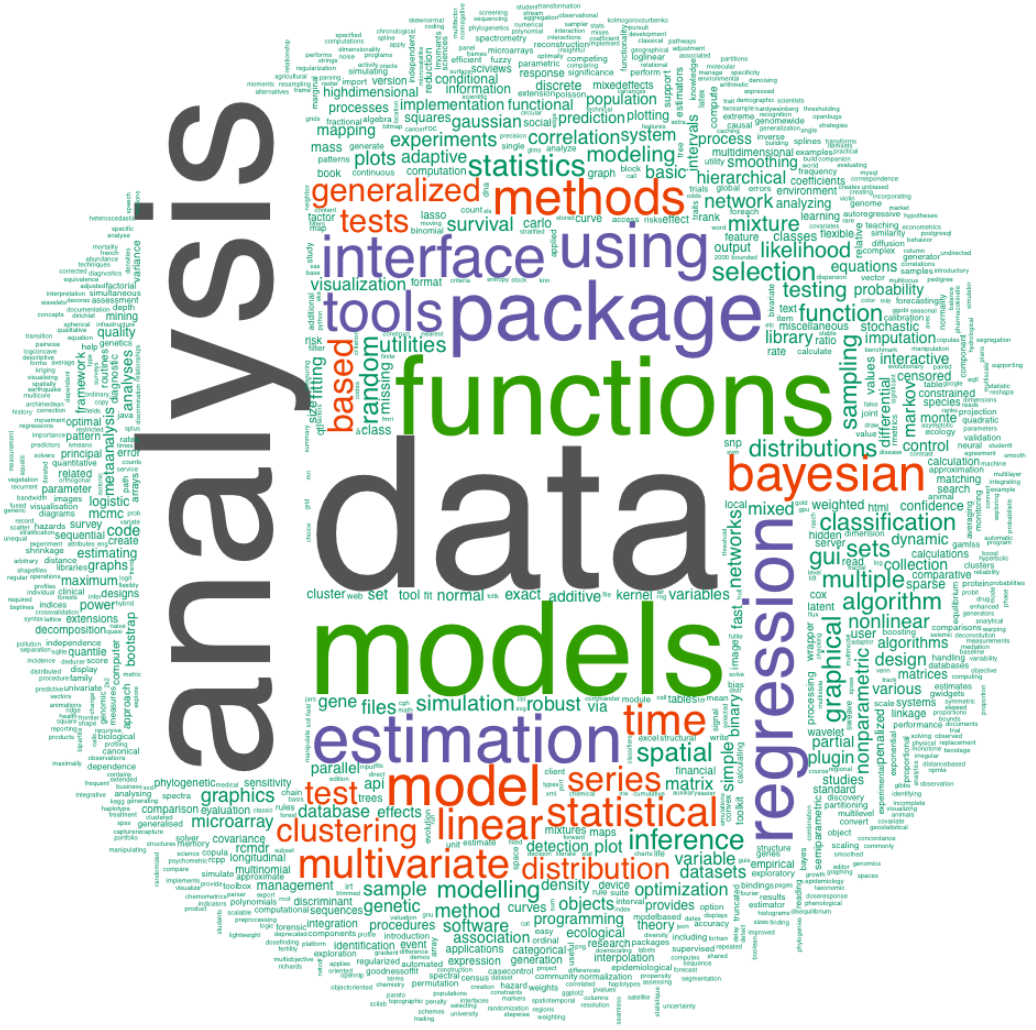
Four Scenarios of Input Detail

- "Defaults" = fully defaulted, except for weather
  - inputs: 1 required
    0 optional]
- "Asset::Visual" = non-intrusive, non-instrumented
  - Inputs: 18 required
    9 optional
- "Asset::Full" = Instrumented audit; more equipment & envelope characteristic data
  - Inputs: 26 required
    16 optional
- "Operational" = Asset::Full + behavioral inputs (interview)
  - Inputs: 28 required; 29 optional

* See https://sites.google.com/a/lbl.gov/hes-public/accuracy/decision-rules

Caveats

- Even the “Operational” scenario was limited in rigor (lighting and misc. appliances poorly characterized in audits)
- Mapping good field-audit data to model inputs is challenging (e.g., duct locations and conditioned basements)
- Not all behavioral factors could be directly accommodated in the model (e.g., vacancy; zoned heating/cooling; use of MELs)



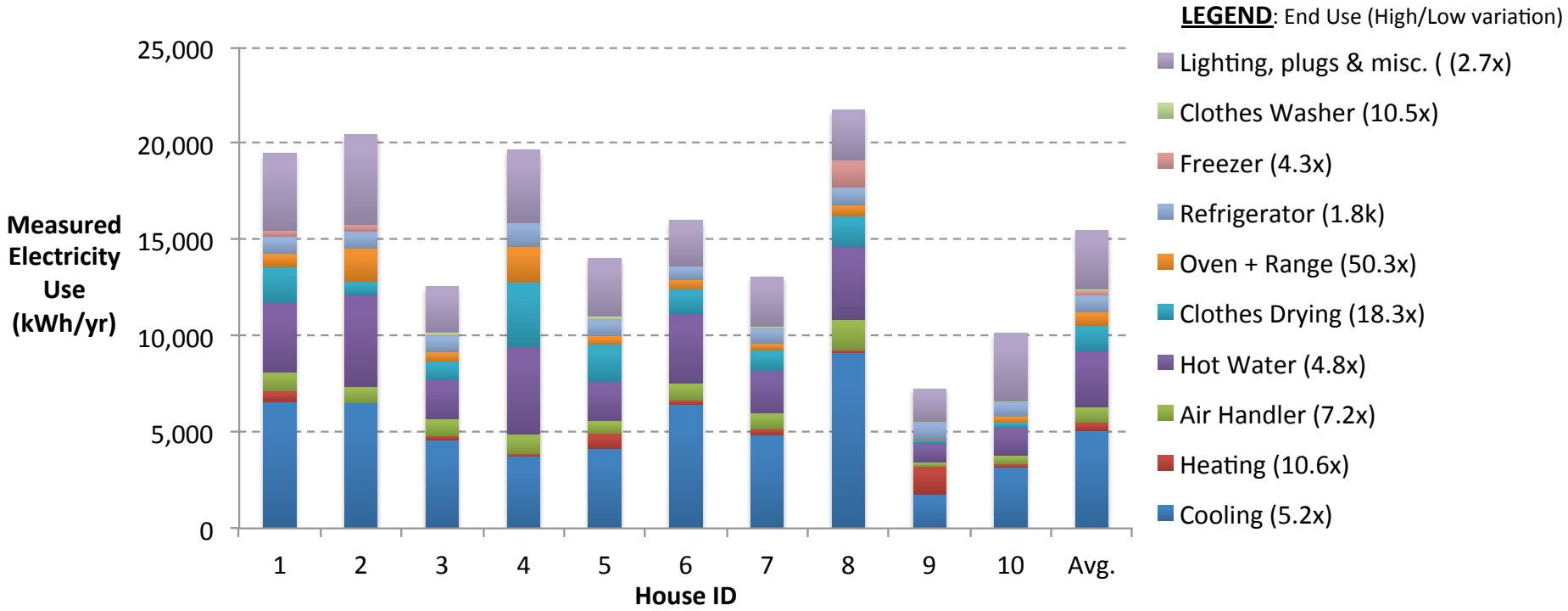
Cohort Characteristics and HES Summary Results for the Four Cohorts of Homes

	FL: Homestead	FL: Florida Power Corp	Wisconsin	Oregon
Sample size	10 homes	171 homes	139 homes	108 homes
Defaults	-15%	-19%	4%	66%
Asset:: Visual	-17%	-7%	68%	56%
Asset::Full	-25%	-5%	7%	19%
Operational	0.5%	1.3%	na	-0.4%

Precision of the results (CV) was also best in each of the Operational cases

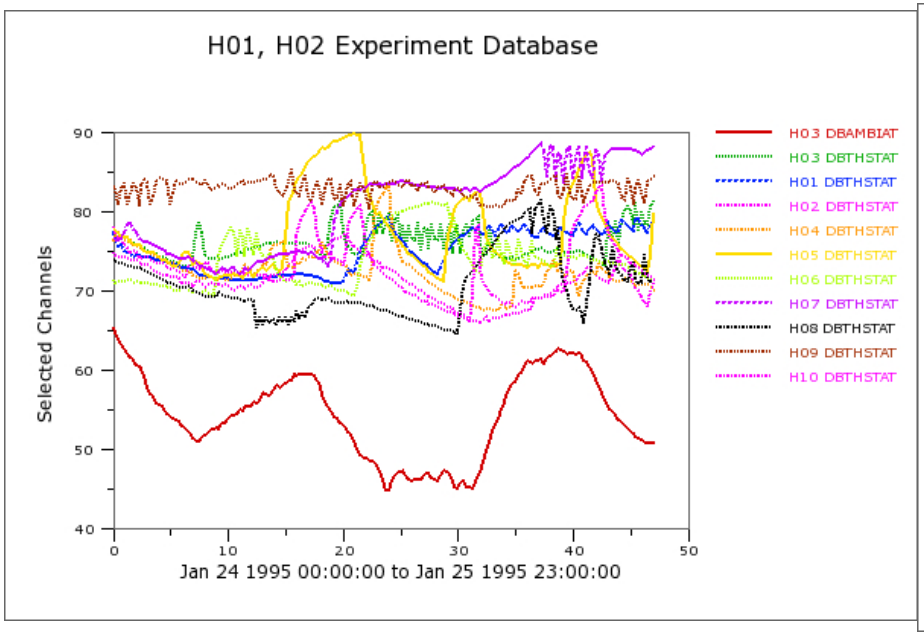
Homestead Cohort: Virtually identical Homes & Efficiencies… … but 3x Variation in Energy Use

- Even greater differences at end-use level
- End-use data extremely valuable for forensic accuracy assessment

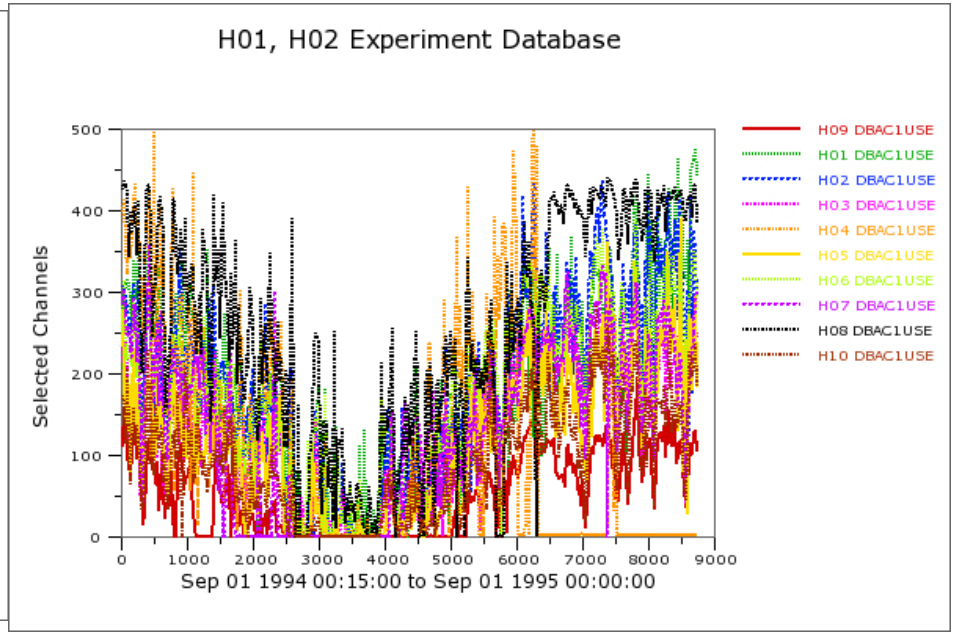


We Benefitted from High-fidelity Interval Data for the Homestead Houses

Interior Temps: Jan. 24- 25th, 1995



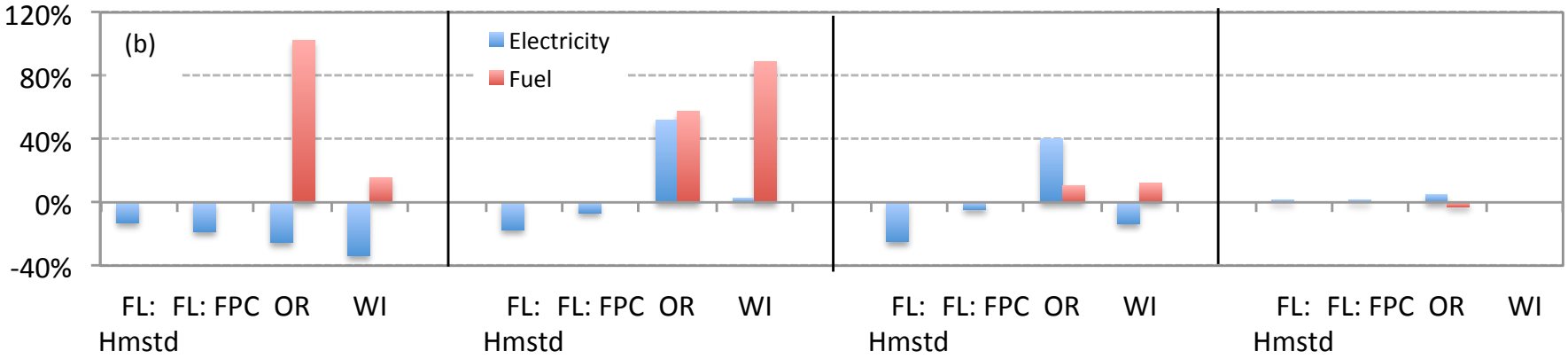
Heating Energy Use: Jan. 24th-25th, 1995



More at https://sites.google.com/a/lbl.gov/hes-public/accuracy/submetered-data

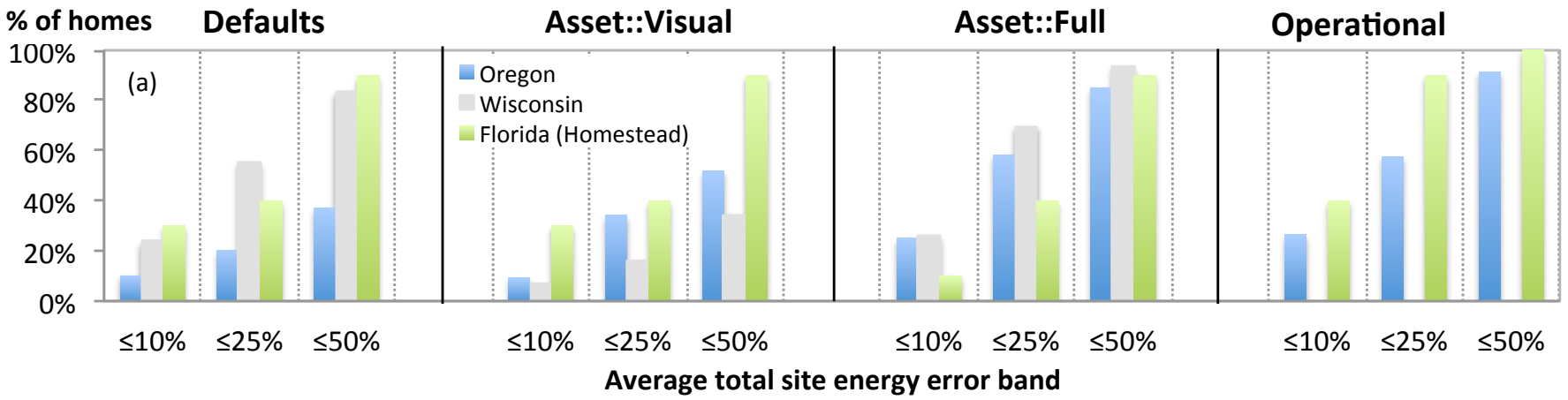
HES Accuracy by (a) Fuel & (b) #Inputs

- "Accuracy" can arise from offsetting errors



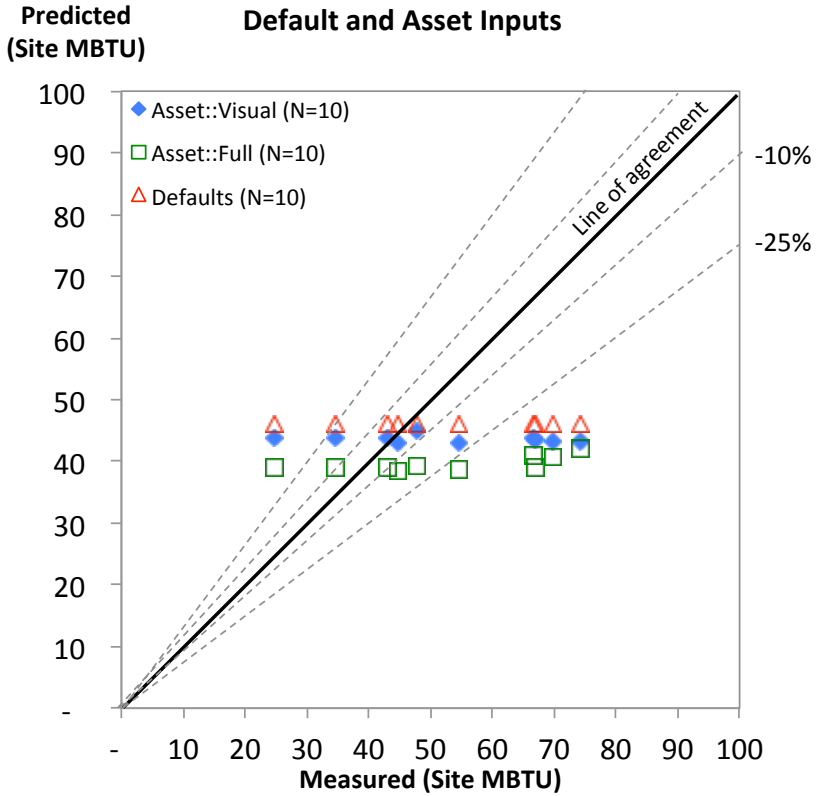
Florida homes are all-electric

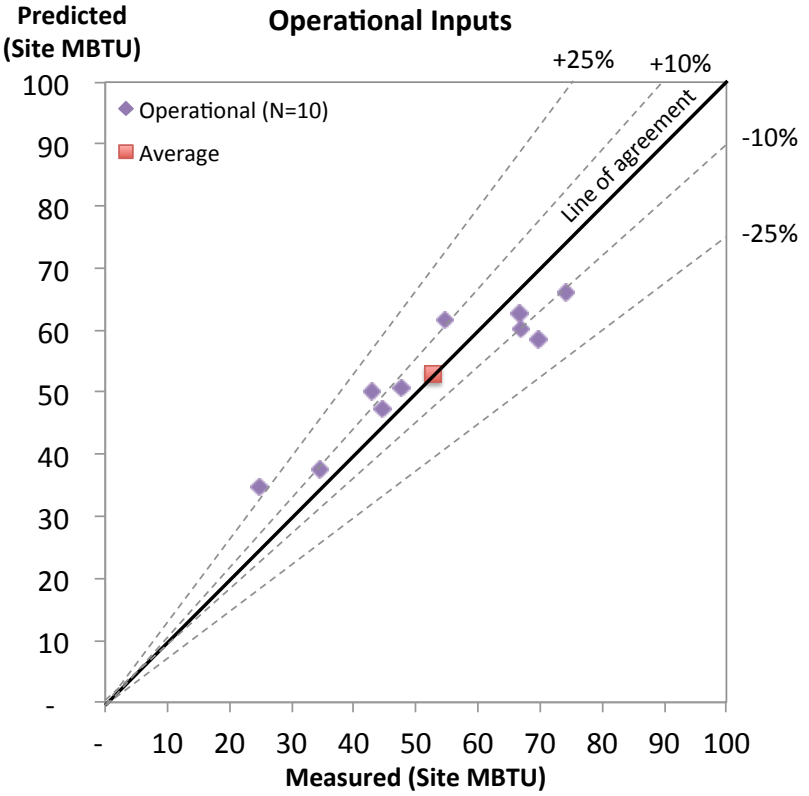
- More inputs <u>can</u> improve accuracy



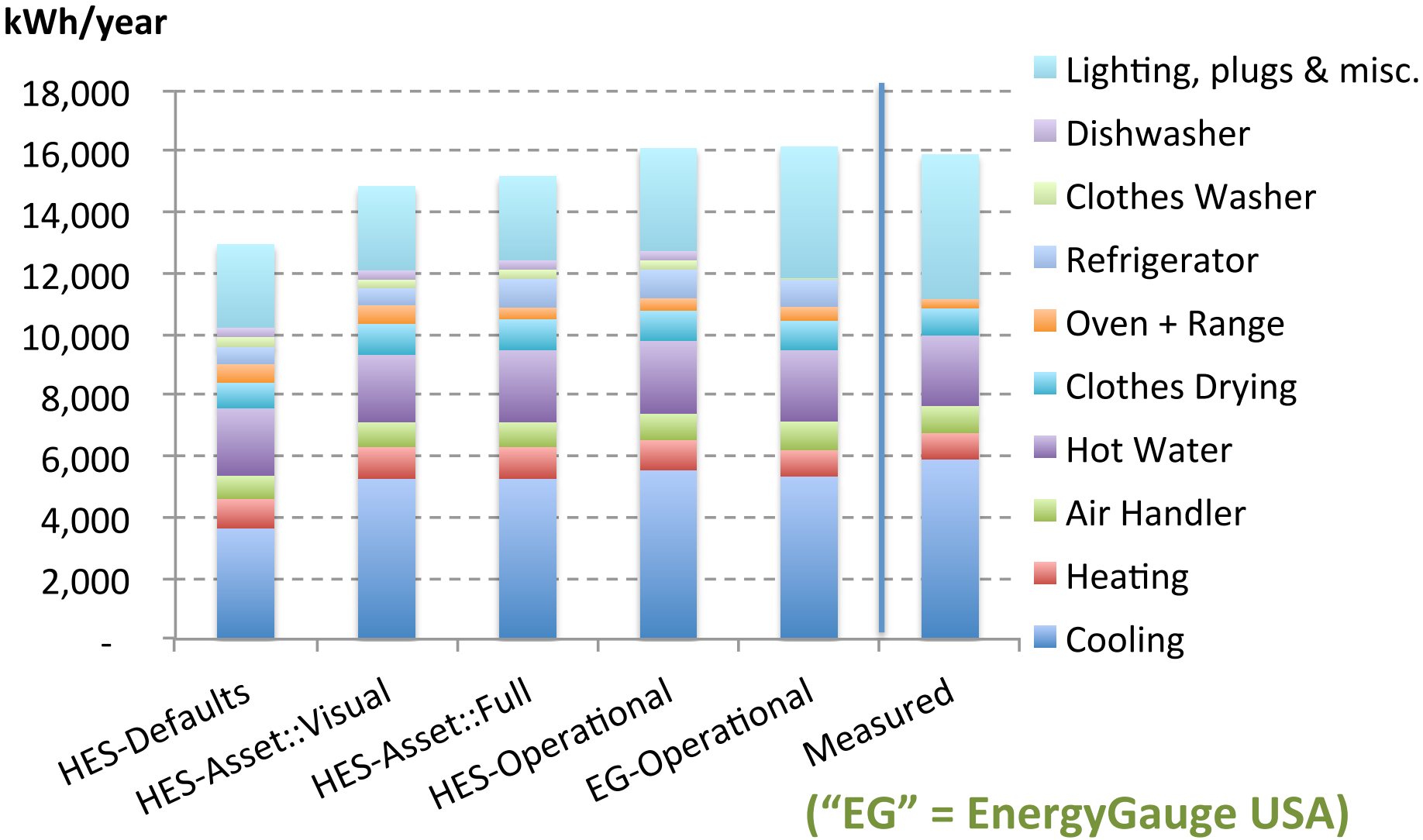
Measured *vs*. HES-predicted Annual Energy Use: Homestead Cohort

- ***Asset*** analysis good on average; but often lousy for specific home
- ***Operational*** analysis accurate within 1% (avg)





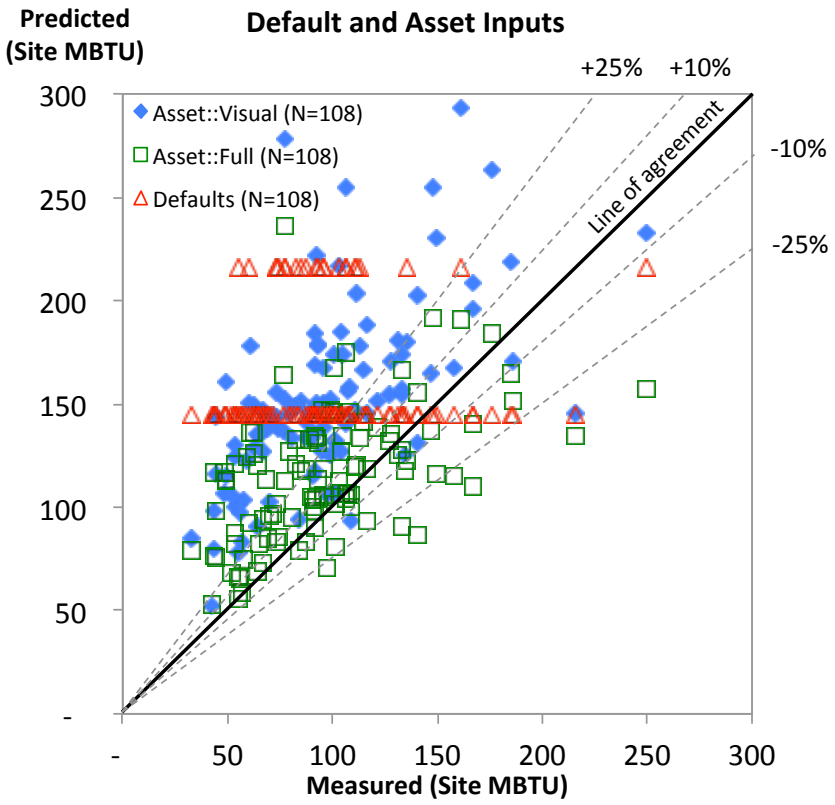
Results by End Use: Central Florida Large Sample

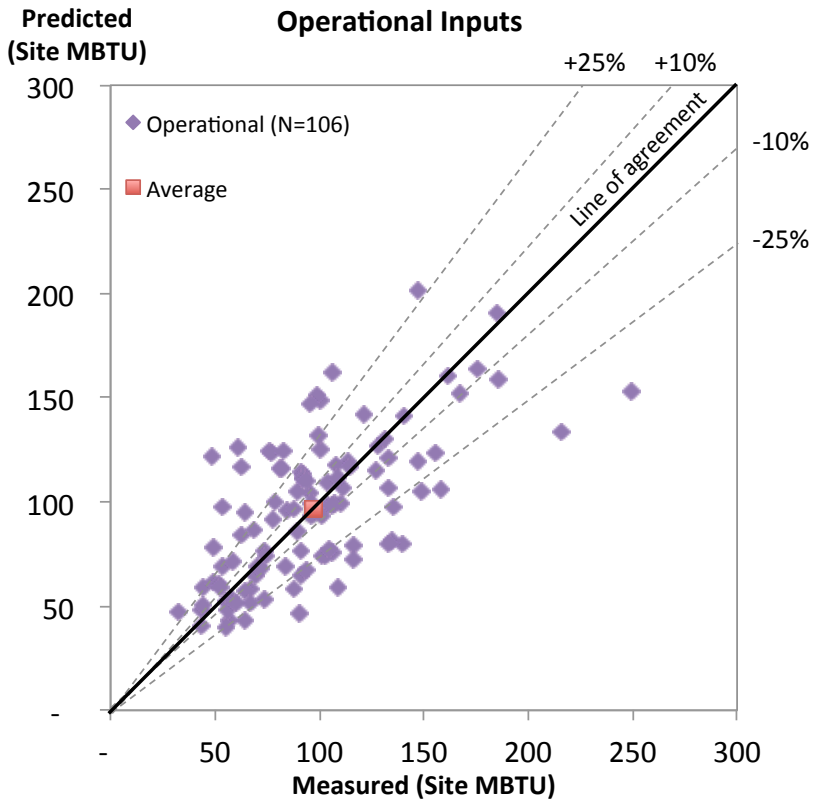


("EG" = EnergyGauge USA)

Measured vs. HES-predicted Annual Energy Use: Oregon Cohort

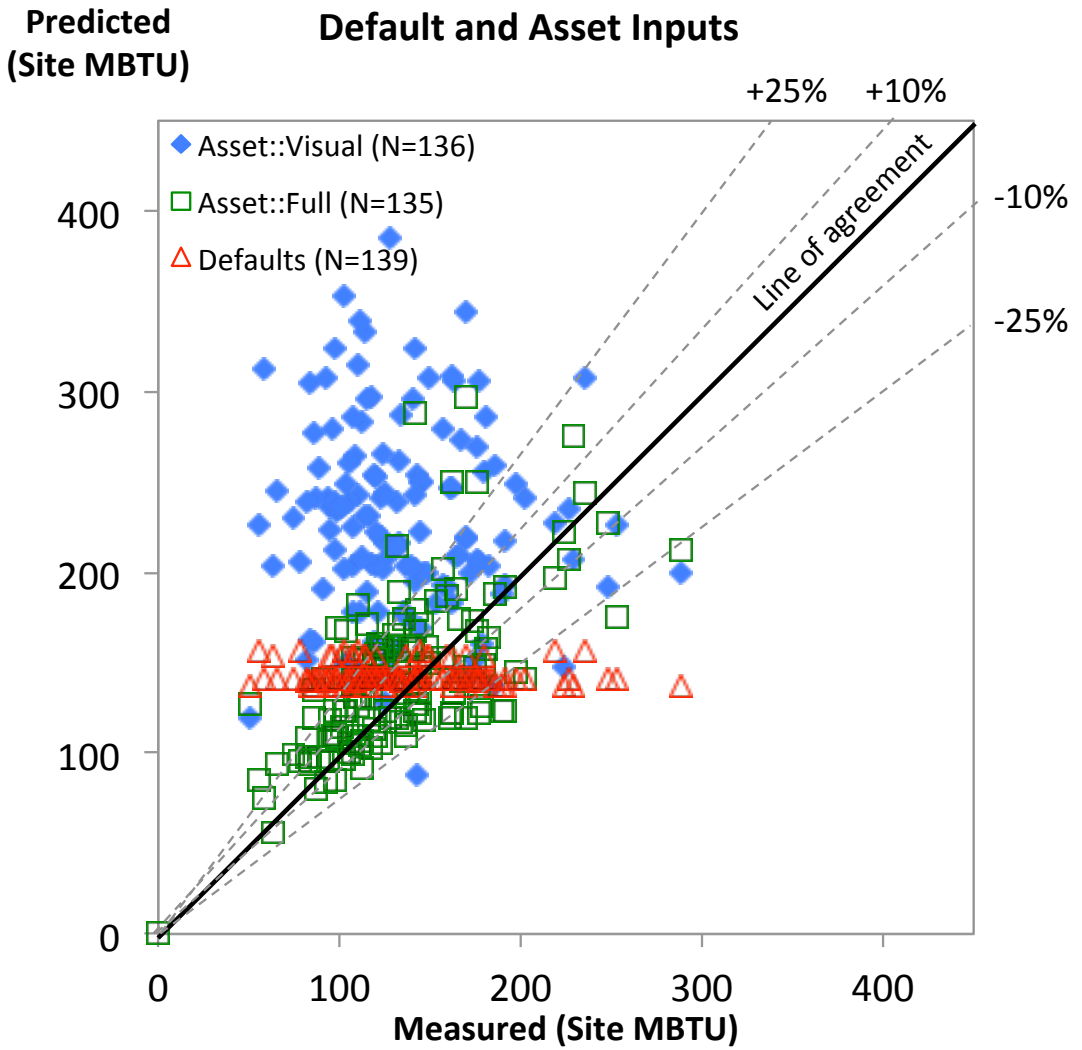
- Asset runs high, improve with increased inputs
- Operational runs accurate to within 1% (avg)





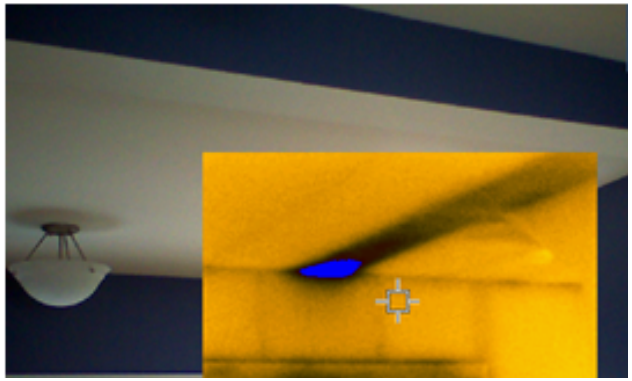
Measured vs. HES-predicted Defaults and Asset Annual Energy Use: Wisconsin

- Asset runs good with Full inputs (w/in 7% on avg)
- Data did not support full operational analysis



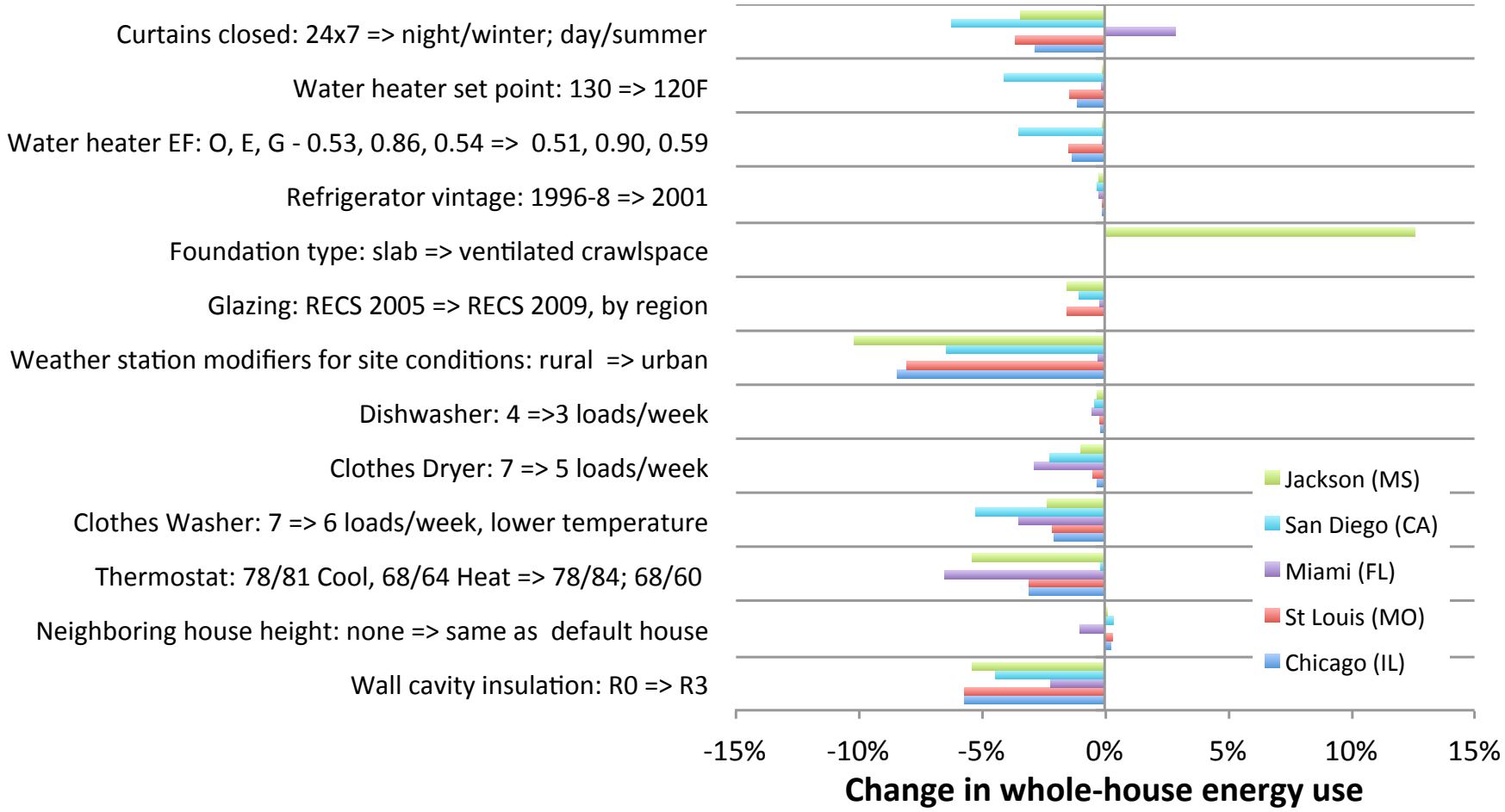
Value of Accuracy Assessment During Tool Development

- Powerful: Compare measured data to model predictions vs. house and equipment characteristics
- Identified bug in air handler/AC algorithm: results went from 75% under-prediction to 1% over-prediction in Florida home sample
- Identified need for updates to duct model, and inappropriate treatment of regain
- Identified and repaired inappropriate free heat from certain appliances (e.g. clothes dryer venting)
- Improvements/updates to defaults, reflecting current housing stock



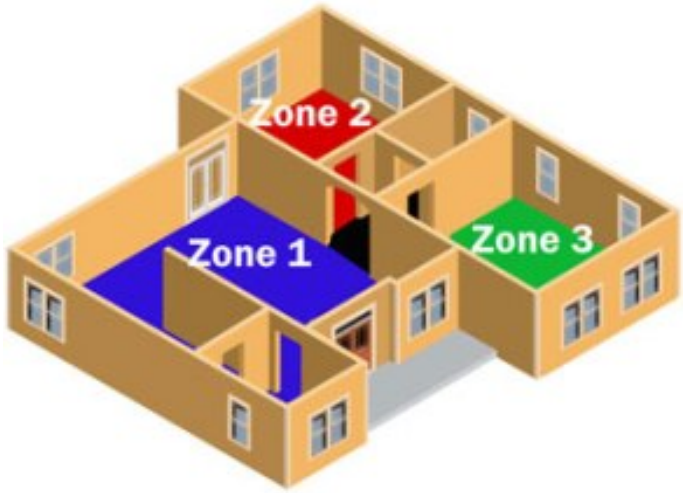
Defaults Assumptions are Important

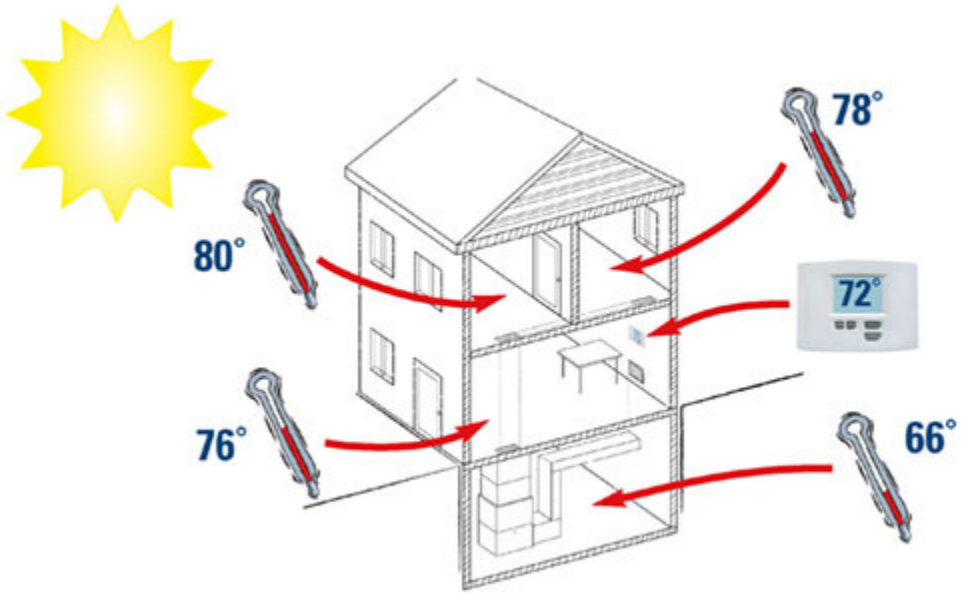
- Sensitivity of HES-predicted whole-house Energy Use to old vs new default assumptions



Future Simulation Enhancements

- Influence of partition walls: interior walls in poorly insulated homes provides significant increases in overall thermal resistance
- Zoning: GRI evaluation in 1980 revealed 30% reduction in heating from zoned vs. central
- Degree of basement conditioning
- Updates to duct model with treatment of regain
- Window heat transfer from curtains/insect screening (empirical & laboratory data)
- Critical inputs emphasis in revised user interface





HES Accuracy: Take-aways

- ***HES Pro: Operational factors brings accuracy to < 1% of actual bills, on average***
  - Minimizes variance relative to asset analyses
  - Accuracy found to be excellent, even at the end-use level
  - Repeatability results in large samples in varied climates
- ***Operational factors have as great an effect on accuracy as do physical characteristics***
  - How occupant operates the house matters at least as much as the house construction and equipment. Major conclusion!
- ***Deficiencies or gaps in audit data erode perceived accuracy***
  - Lighting and miscellaneous energy use are important
- ***Accuracy assessments (prediction vs. data) aid model development***
  - Errors often offset one-another; can give false illusion of accuracy
  - End-use data particularly useful to address such issues
- ***Building simulation community now capturing important nuances*** (e.g., basement thermal performance)
- ***Improved modeling of lighting/miscellaneous energy and zoning are important to further improvements in accuracy***